Appendix C

Operational Alternatives - Technical Summary

APPENDIX C

OPERATIONAL ALTERNATIVES - TECHNICAL SUMMARY

Background. A revised operational plan is being developed for the Cougar Lake Project, Willamette River Temperature Control as part of a Supplemental Information Report (SIR) which will address high turbidity levels in the South Fork McKenzie River below the project associated with the Spring 2002 drawdown of Cougar reservoir. The revised plan will cover the entire construction sequence for this project.

Spring 2002 Drawdown. Reservoir drawdown at Cougar began at a rate of 3 feet per day. A major April rainstorm delayed completion of drawdown. The process was halted on May 26, 2002, at elevation 1,400 feet instead of the projected 1,375 feet due to unexpected high levels of turbidity. Figure 1 shows the pool elevation, releases and turbidity measured immediately downstream of the project.

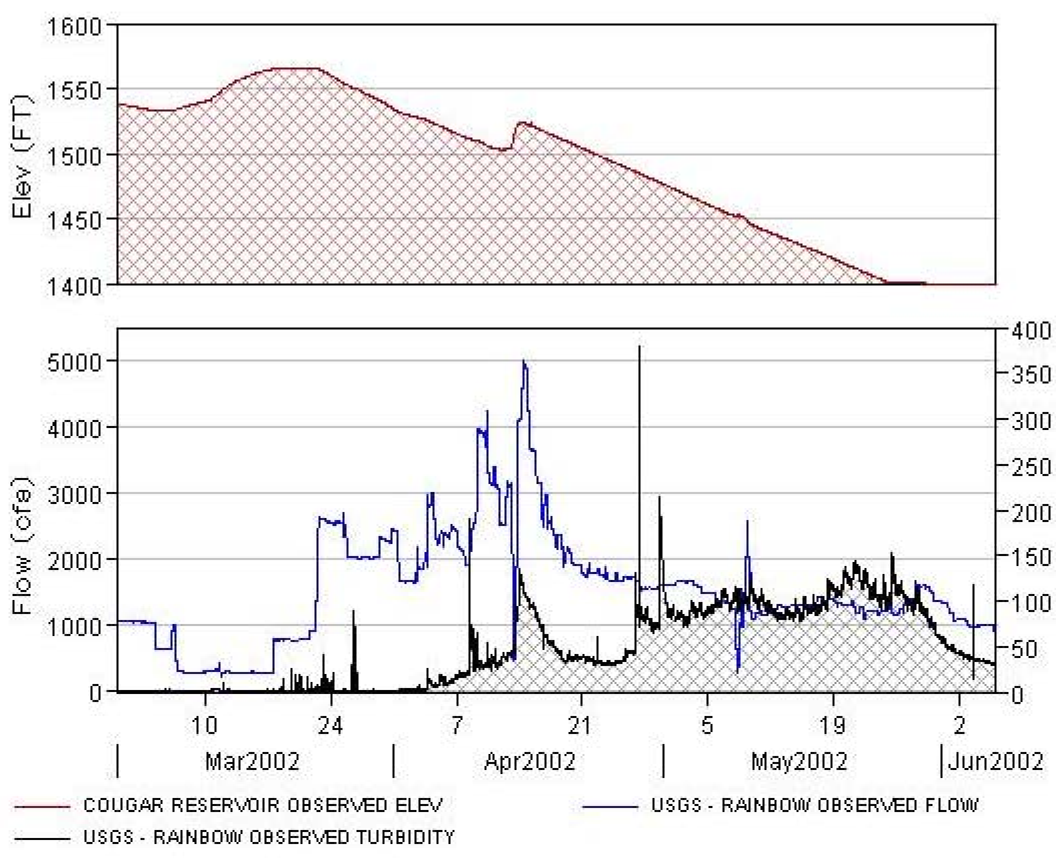

Figure 1 - Measured turbidity downstream of Cougar Dam vs. pool elevation and releases - 3/01 - 7/6/02

Proposed Revised Operating Plans. The proposed actions available for reducing the high spring turbidity associated with drawdown were increasing the drawdown rate below pool elevation 1532 ft, adjusting the winter flood control pool, and target date to reach the residual or construction pool of 1400 ft. These proposed actions were combined into six alternative operational plans. A target date of March 1st for drawdown to 1400 is desired, as it gives a month to flush out any residual turbidity in the lower pool prior to the start of construction on April 1. Table 1 summarizes the alternative plans studied.

Table 1 - Cougar SIR Operational Alternative plans

Alternative	Target date	Drawdown rate	Winter Pool Elev.
LP1	-	3 ft/day	1400 ft
LP2	-	6 ft/day	1400 ft
HP1	March 1	3 ft/day	1532 ft
HP2	April 1	3 ft/day	1532 ft
HP3	March 1	6 ft/day	1532 ft
HP4	April 1	6 ft/day	1532 ft

Advantages and disadvantages for maintaining the pool this winter at or near elevation 1,400 feet are listed below.

Advantages:

- Widening and armoring of existing channel feeding lower reservoir pool due to winter flows, reduced risk of old channel abandonment/new channel formation.
- Higher probability of reaching elevation 1,400 by March 1 if there is a high-water event during the winter. This is because of the lower residual pool elevation prior to the high-water event (i.e., there is a higher probability of having a lower pool elevation after storing a flood).
- During the winter, a shorter timeframe for flushing turbid water from the residual pool because of the lower volume and detention time.
- Vegetation established below 1,532 feet during summer 2002 would not be drowned out, and become better established. This would reduce erosion in the lower pool, thereby reducing sources of turbidity within the reservoir. Turbidity in succeeding years would be reduced as a result.

Disadvantages:

- Higher turbidity during the winter. Increased number of turbidity events and increased turbidity associated with each event. Rapid rises in the pool level during winter storms will result in erosion of exposed sediments surrounding the residual pool.
- Higher and more variable flows downstream of the reservoir during the winter.

Advantages and disadvantages for filling the reservoir to elevation 1,532, then drawing it back down again in mid-January are listed below.

Advantages:

- Reduced probability of turbid flows below the dam during the winter if the reservoir fills with clear water, or following clearing of turbidity from the reservoir after it fills.
- Reduced or more normal winter turbidity downstream of Cougar reservoir during the filling period.

Disadvantages:

- Increase in risk that a new channel could be formed during the next drawdown to 1,400 ft. The new channel would cut through erodable material in the mid pool area transporting more material to the lower reservoir pool, increasing turbidity of the pool overall.
- Higher risk of increased turbidity below the dam during the spring as sediment re-distributed and deposited in the reservoir channel during inundation is re-suspended during drawdown.
- Lower probability of reaching el. 1,400 by March 1 if there is a mid-January or mid-February high-water event. A high-water event in mid-January or mid-February would impact the timing and duration of drawdown increasing the chance of turbid flows in the spring.
- Longer timeframe for flushing turbid water from the reservoir over winter because of the larger volume and longer detention time. However, turbidity would not peak as high.

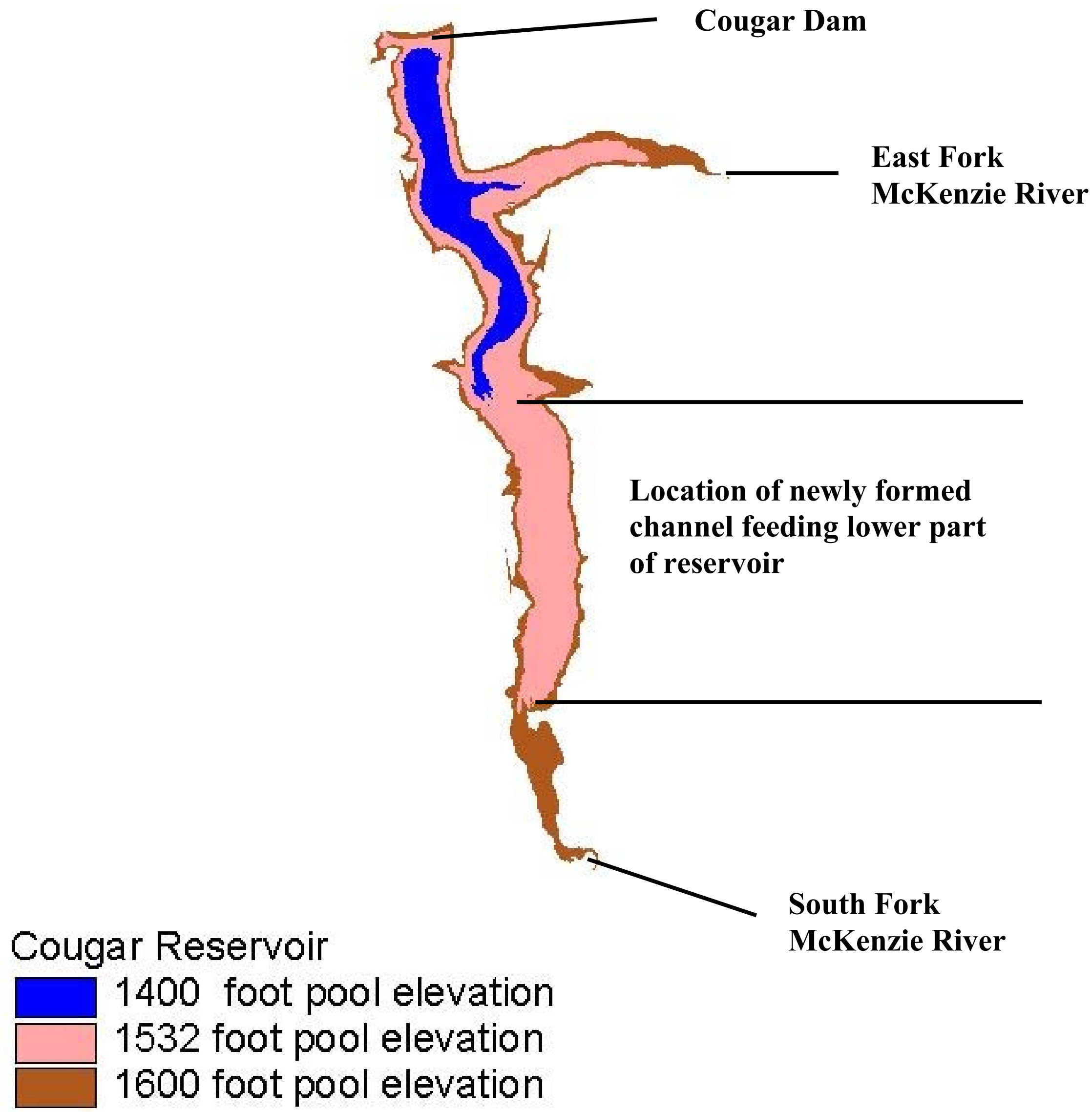

Figure 2 - Map of Cougar Reservoir showing approximate extent of 1400 and 1532 ft pool levels and location of tributaries feeding the reservoir.

<u>Modeling of Proposed Alternative Plans</u>   In order to assess the potential effects of the six proposed operational plans on the McKenzie River system and Blue River Reservoir, system analysis was performed using HEC ResSim, a computer model specifically designed for reservoir operational analysis,

The McKenzie River system was modeled to Vida, OR, the control point on the lower McKenzie (Figure 3). Blue River and Cougar reservoirs were operated for flows immediately downstream (maximum flows 3700 and 6500 cfs respectively) and at Vida (maximum flow - 14,500 cfs). Minimum flows at Blue River and Cougar were 50 and 250 cfs respectively.

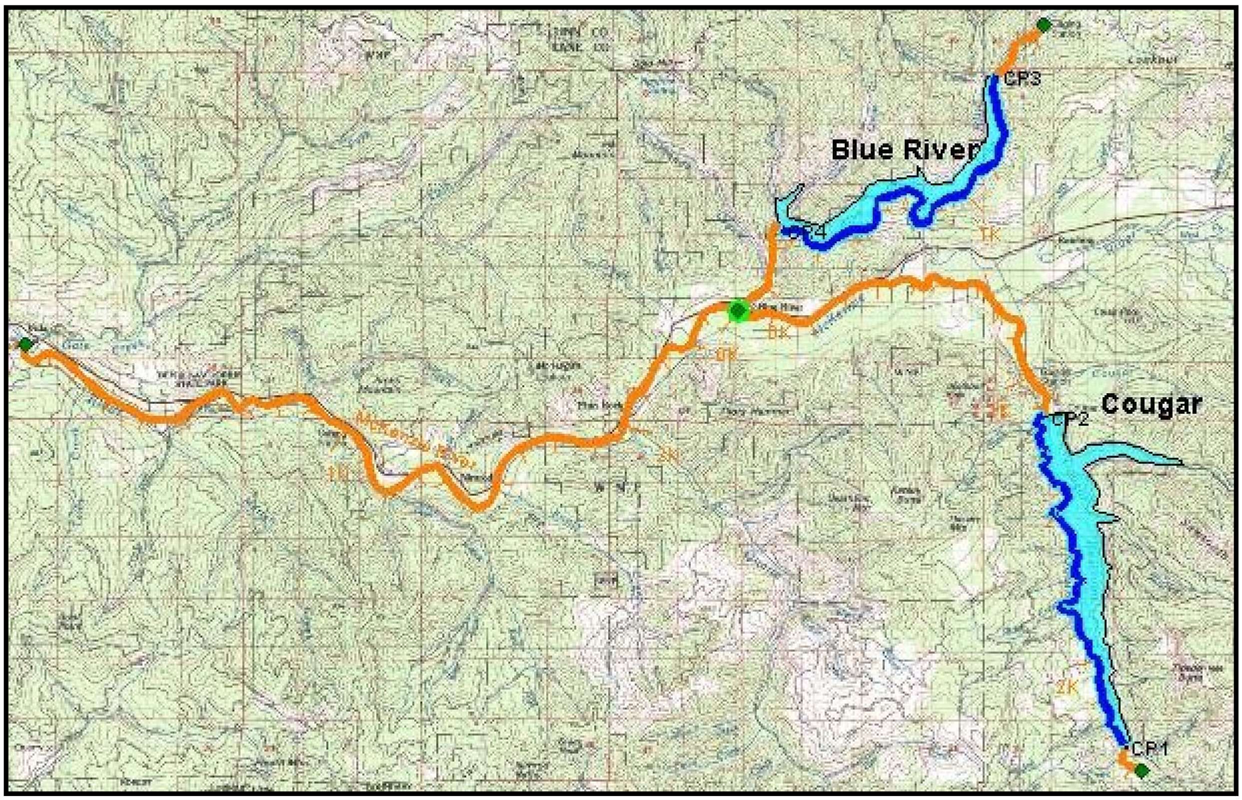

Figure 3 - Schematic diagram of McKenzie River system model

Outlet Capacity. Cougar reservoir is currently utilizing a diversion tunnel, in addition to the regulating outlets used during normal operation. All releases below pool elevation 1510 feet are made through the diversion tunnel.

The Regulating Outlets and Emergency Spillway release capacities were also defined in the model. Figure 4 shows rating curves for the diversion tunnel, and combined diversion tunnel and regulating outlets. The Regulating Outlets and Emergency Spillway rating curves for Blue River were used to develop the reservoir model for Blue River.

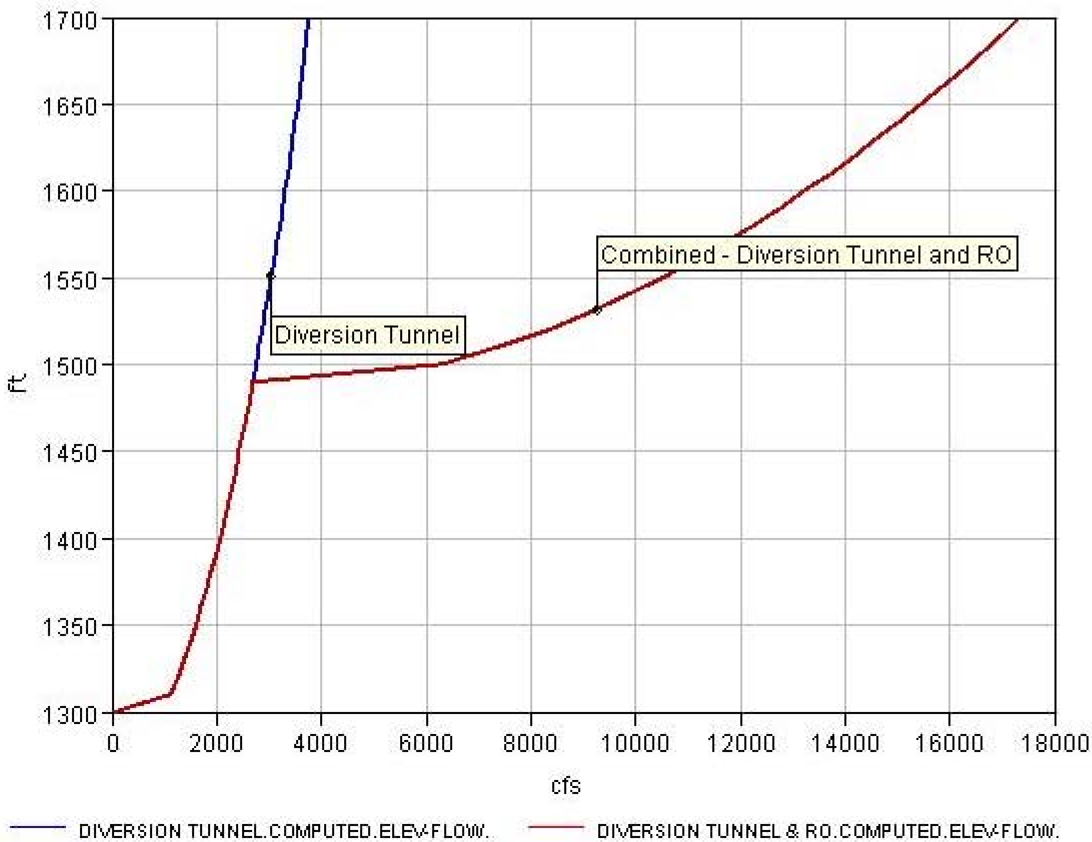

Figure 4 - Cougar Reservoir - Rating Curves for Diversion Tunnel, Combined Diversion Tunnel and Regulating Outlets.

Operational Alternatives The six operational alternatives for Cougar were modeled using guide curves to define the target pool elevations and target dates. Rules were used to define maximum and minimum flow targets downstream of the dam and at Vida, drawdown rates, and spillway releases. A simulation representing normal operation for Cougar (pre-WTC construction) and Blue River was run for comparison. Guide curves for normal operation for Cougar and Blue Rive are shown in Figure 5. The Blue River operation was defined using its normal operational guide curve. Rules were used to define maximum and minimum flow targets downstream of the dam and at Vida, and spillway releases. The guide curves used for the low and high pool alternatives are shown in Figure 6.

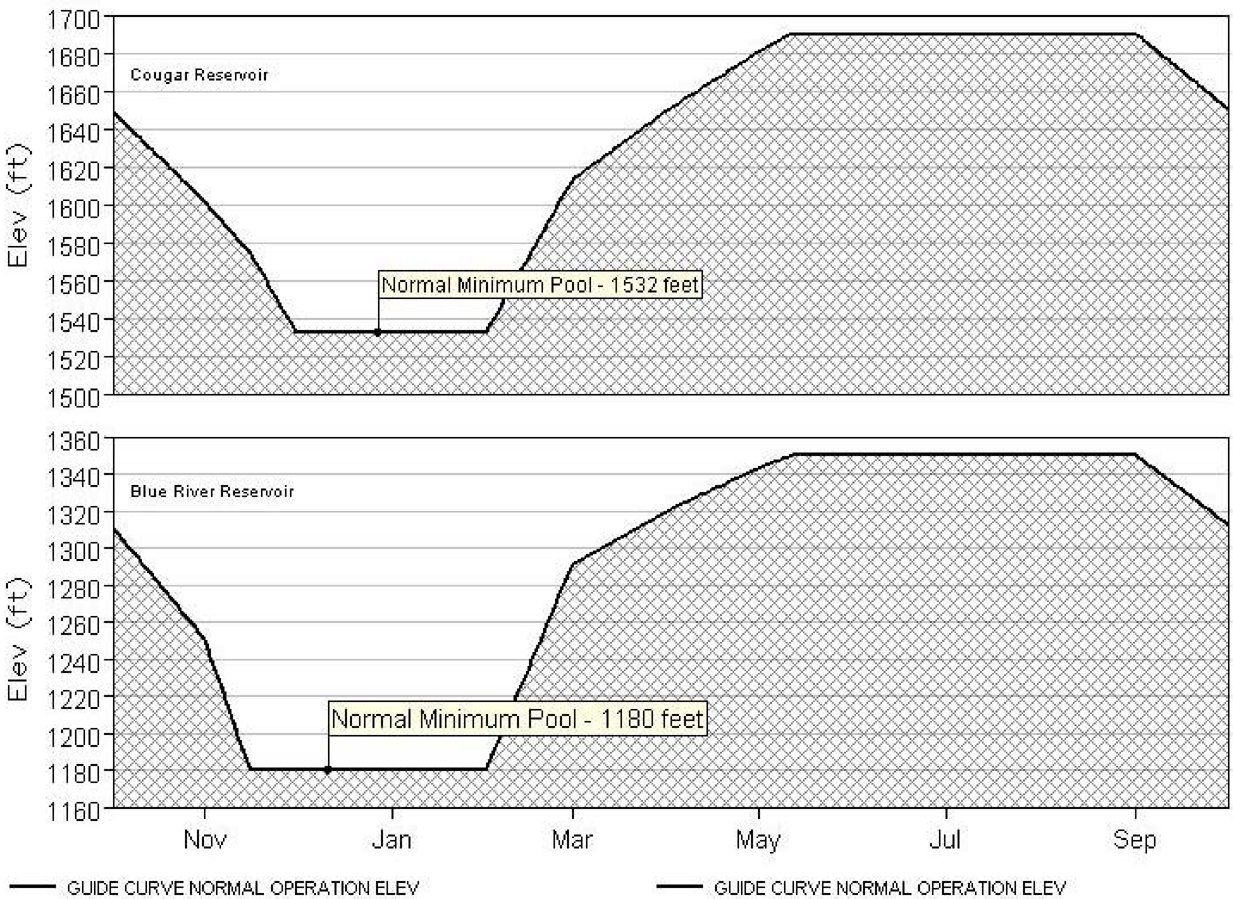

Figure 5 - Normal Operational Guide Curves for Blue River and Cougar (Pre-WTC construction)

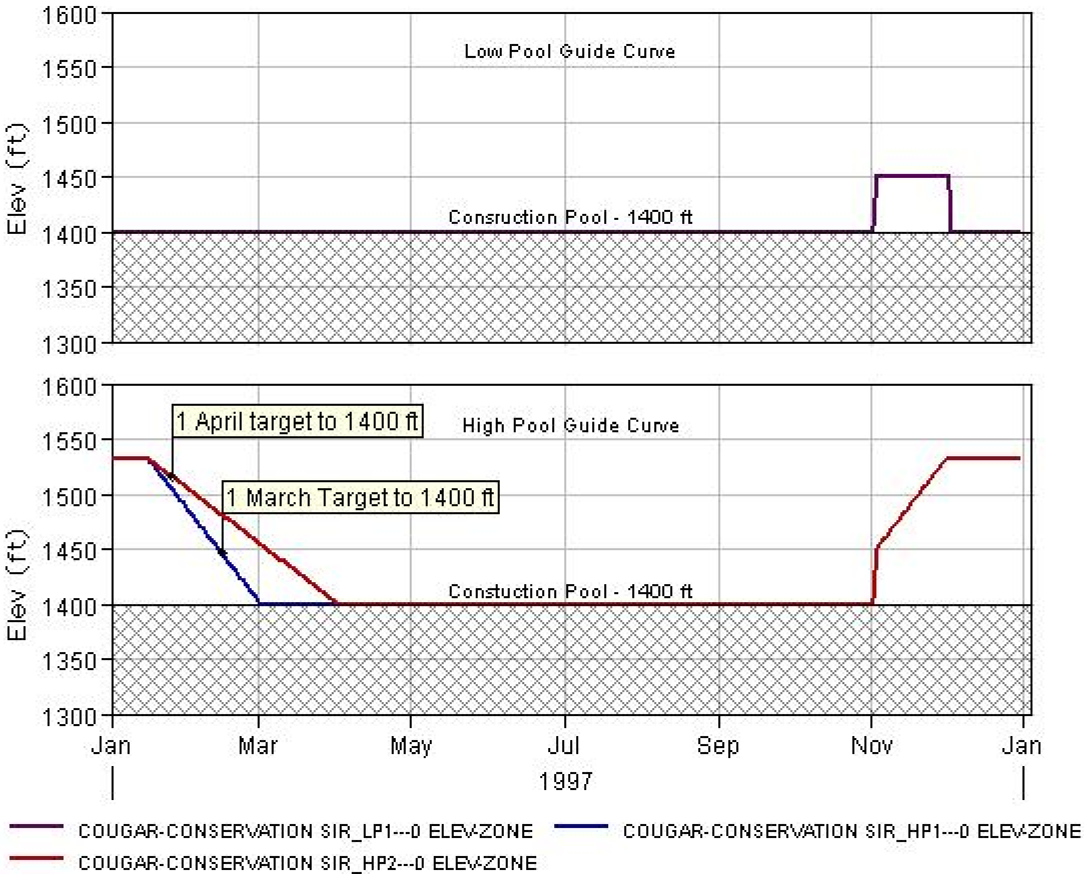

Figure 6 - Guide Curves for Cougar Reservoir, Low and High Pool alternatives

The high pool guide curve commences drawdown of the reservoir on January 15th, 16 days earlier than under normal operation. The start of drawdown is advanced in order to increase the probability that the reservoir pool will be at 1400 feet by the March 1st through April 1st time period.

Modeling of Alternatives. In order evaluate the effect of the alternatives on the McKenzie River System and determine the probability of having the pool at 1400 feet by March 1, a simulation using daily mean flows was run from 1935 through 1998. A simulation using hourly data was run from Oct 2001 through June 2002, to assess the performance of the alternatives on last year's operation. An additional simulation was run from November 1996 through March 1997 to assess the effects of holding the pool at 1400 feet in a high water year.

Results – 1935 through 1998 daily mean flows Results of the modeling showed that the alternatives with the best chance of meeting the March 1st target date were HP3 and LP2. Both alternatives incorporate the 6-ft/day drawdown option. Figures 7 and 8 show the 90 percent non-exceedance plot of the high and low pool alternatives. Tables 2 and 3 show 10 through 90 percent non-exceedance values at March 1st and April 1st.

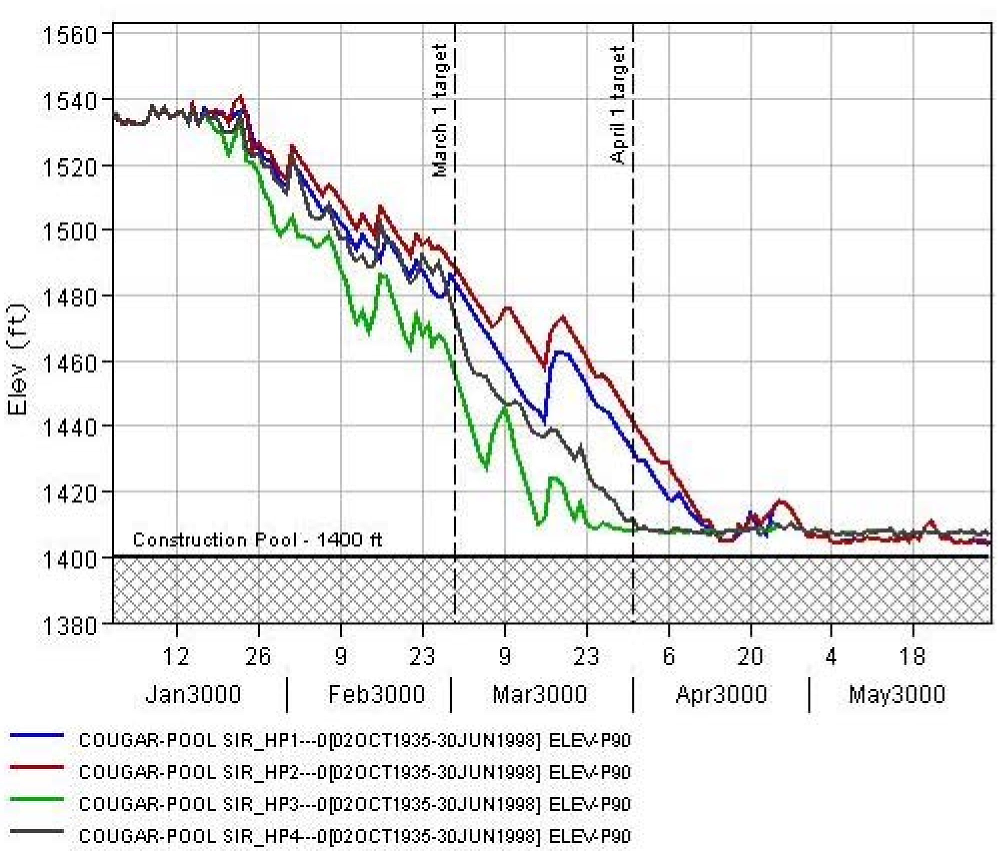

Figure 7 - Cougar Reservoir High Pool operational alternatives, 1 March target date - 90% non exceedance pool elevations (January to May)

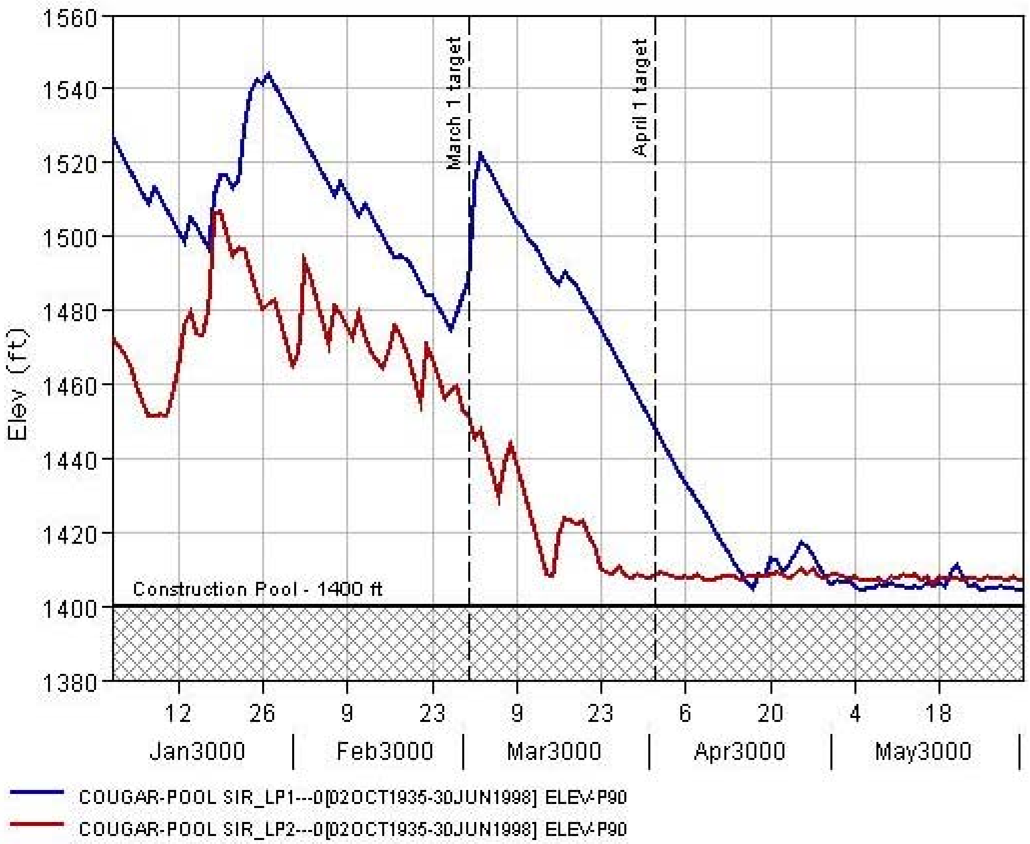

Figure 8 - Cougar Reservoir Low Pool operational alternatives - 90% non exceedance pool elevations (January to May)

Table 2 – Cougar Pool Elevations (in feet) , 10 - 90 % non-exceedance probabilities at March 1st

Alternative	10 %	25%	50%	75%	90%
HP1	1404	1405	1412	1443	1483
HP2	1454	1456	1457	1460	1488
HP3	1401	1403	1406	1412	1455
HP4	1454	1456	1459	1461	1472
LP1	1400	1401	1404	1435	1464
LP2	1396	1400	1403	1407	1447

Table 3 - Cougar Pool Elevations (in feet), 10 - 90 % non-exceedance probabilities at April 1st

Alternative	10 %	25%	50%	75%	90%
HP1	1399	1400	1402	1405	1429
HP2	1401	1402	1404	1405	1439
HP3	1396	1400	1402	1407	1409
HP4	1400	1401	1403	1407	1409
LP1	1399	1400	1403	1404	1422
LP2	1396	1399	1401	1406	1409

Recommended Alternative. If the reservoir pool were raised to elevation 1532 feet, it would only be maintained at that elevation for about 6 weeks. As such, most of the benefits of keeping the reservoir pool at elevation 1532 feet may not be realized. In addition, the difference between the two elevation alternatives is only significant for an average or below average water year. An above average water year does not significantly favor either alternative.

Given the number of advantages for maintaining the reservoir pool at or near elevation 1400 feet, the preferred operational alternative is to keep the pool at or near elevation 1400 feet for the next two flood control seasons using a drawdown rate of 6 ft/day below elevation 1532 feet (LP2).

March 2002 through June 2002 simulation under selected alternative A simulation was run with alternatives LP1 and LP2 to determine the pool levels and releases, which would have resulted during the late spring storm under the different rate of drawdown scenarios. Figure 9 shows a comparison of spring 2002 pool levels under LP1 and LP2.

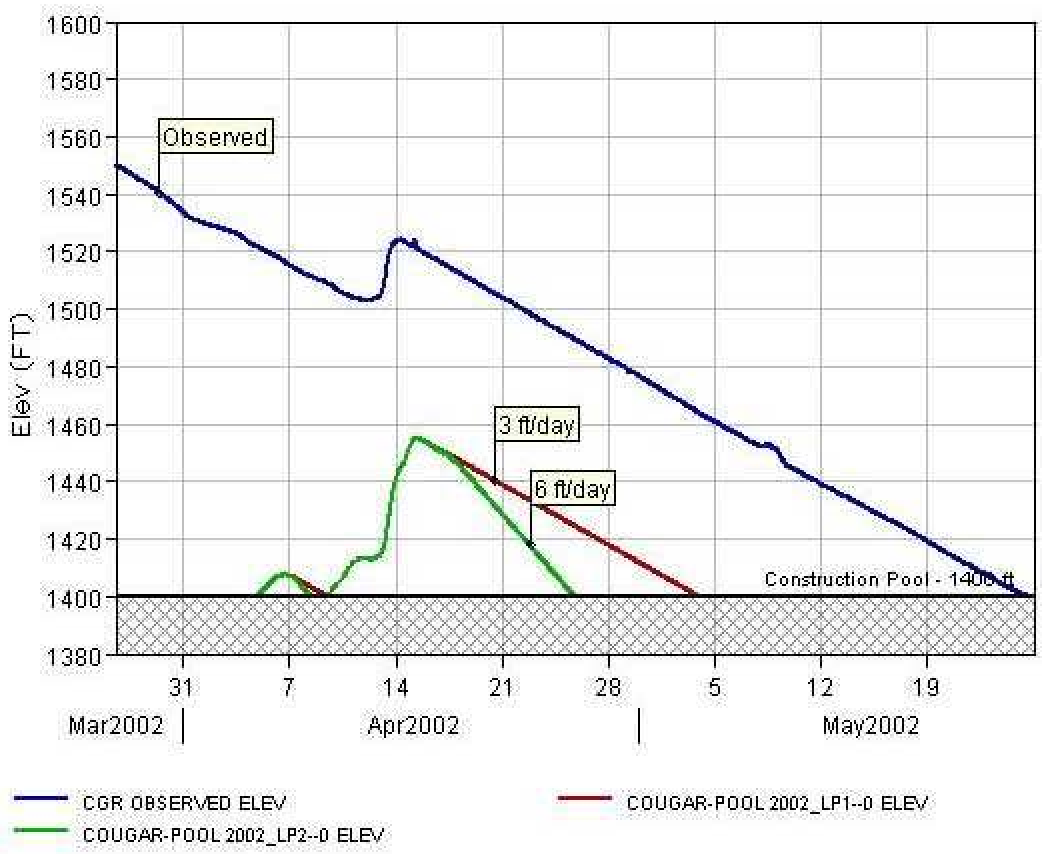

Figure 9- March - May 2002 Cougar Observed Pool Elevation vs LP1 and LP2

The late spring rain event would have raised the pool elevation to 1455 feet on April 16th. The pool would have been drawn down back to 1400 feet by April 26th under LP2 and May 3rd under LP1. It is probable that turbidity levels would have still been elevated during this period, however the duration of the elevated turbidity levels would have been reduced significantly from what occurred in last year when the pool reached 1400 feet on May 26th. Using a 6-ft/day drawdown rate decreased the duration of the drawdown by 8 days vs. using a 3ft/day drawdown rate.

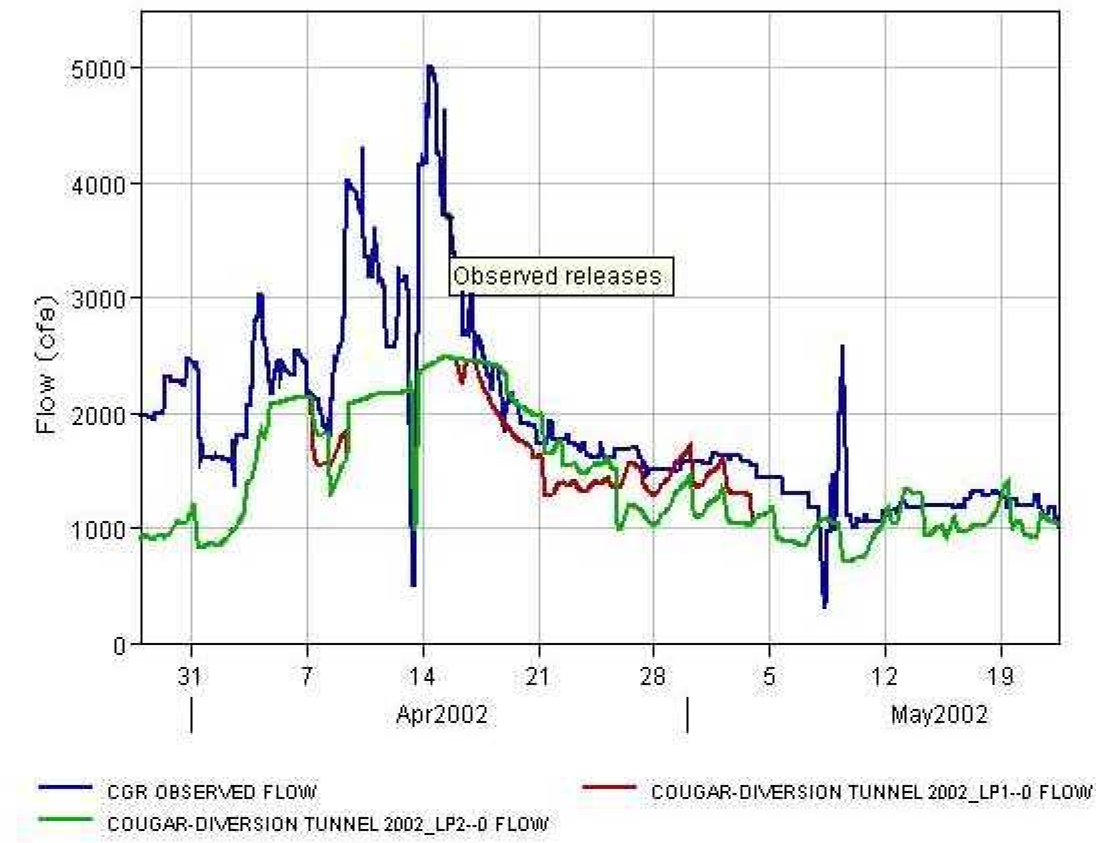

Figure 10 -Comparison of April – May 2002 Cougar releases with LP1 and LP2

Results – Winter 1996- 1997 flows A simulation was run from November 1996 through March 1997 to assess the effects of holding the pool at 1400 feet in a high water year. Under LP1, the maximum pool level reached was 1655 feet on Jan 4. On March 1, the pool was at 1457 feet and 1404 feet on April 1. Under LP2, the maximum pool reached was 1642 feet on Jan 4. On March and April 1 the pool was at 1400 feet. The results show that under LP2, the pool would be at 1400 feet at March and April 1 in a high water year. Figure 11 shows pool levels under LP1 and LP2, November 1996 through March 1997.

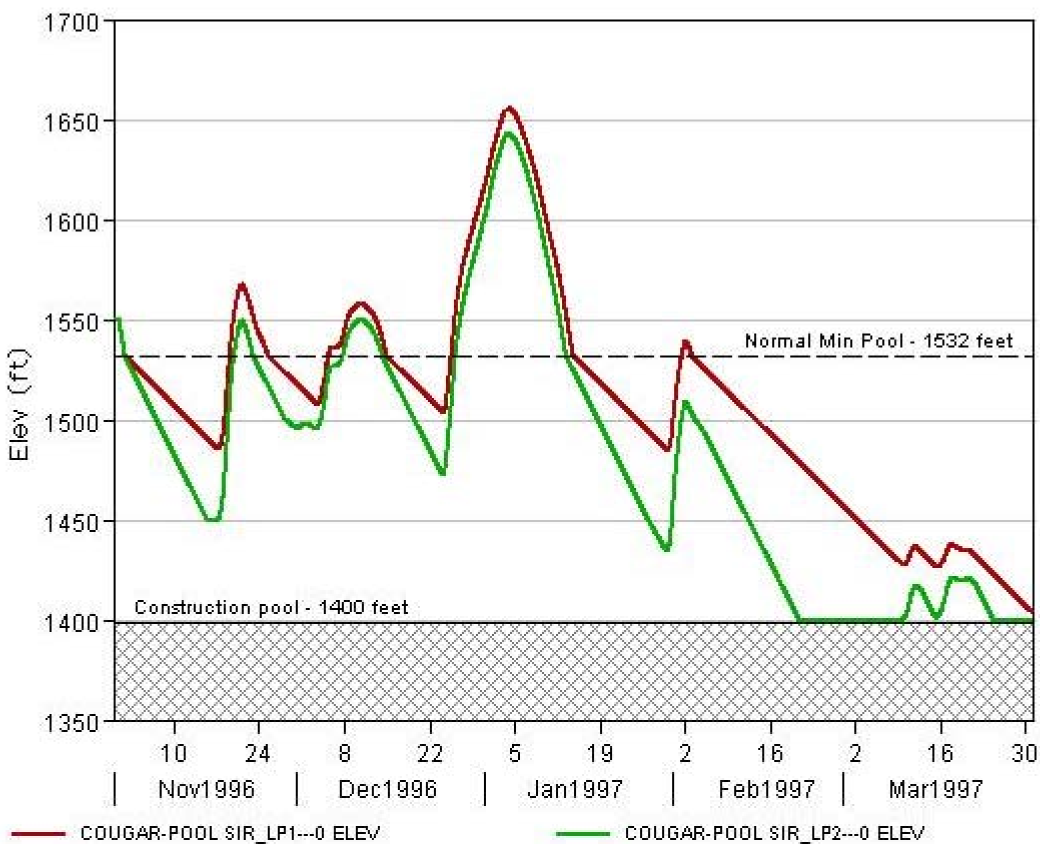

Figure 11 – Cougar Reservoir Pool levels, Winter 1996-1997 under LP1 and LP2.

<u>Impact to flows at Vida, Oregon</u>   The 50 percent (median) non-exceedance plots comparing normal flows at Vida with the six alternatives show that the discharge in the main stem McKenzie at Vida will be higher in all cases. This is due to the elimination of summer or conservation storage pool that would normally be in place. Thus, water that would normally go into reservoir storage is contributing to mainstem McKenzie River flows.   As expected, the alternatives with the higher drawdown rate will cause more variability in flow (Figures 12 – 14).

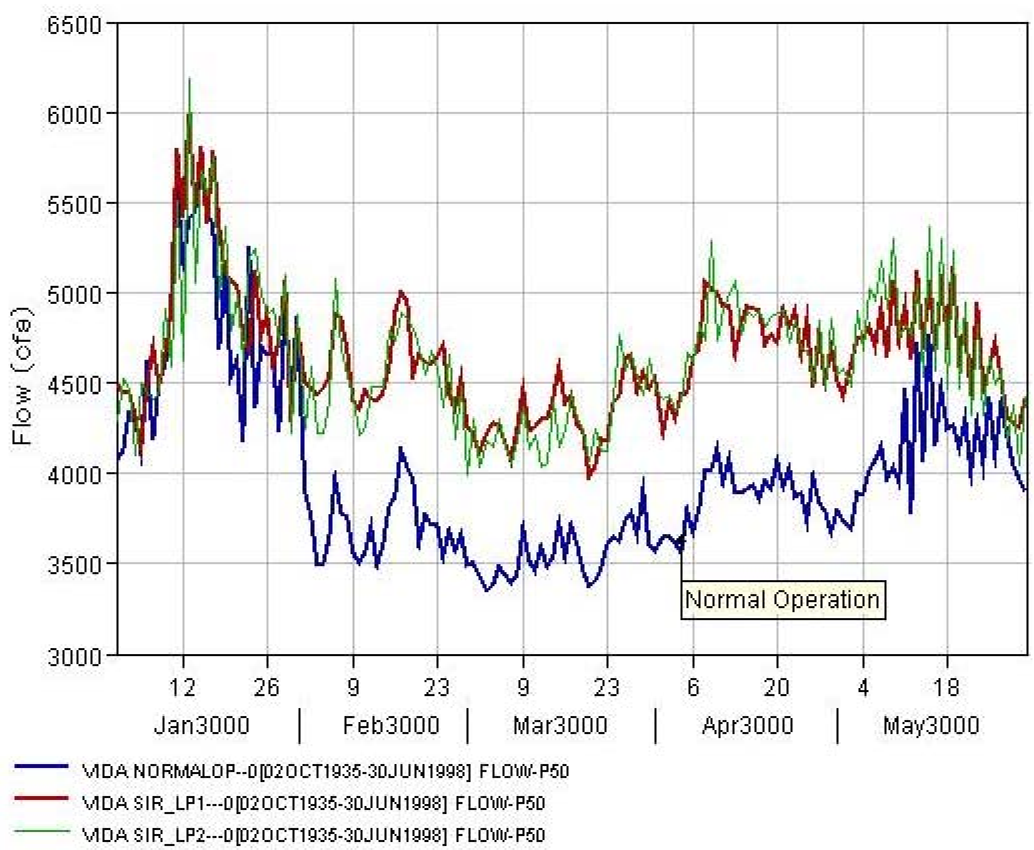

Figure 12 - Comparison of flows at Vida, OR. Normal Operation vs LP1 and LP2.

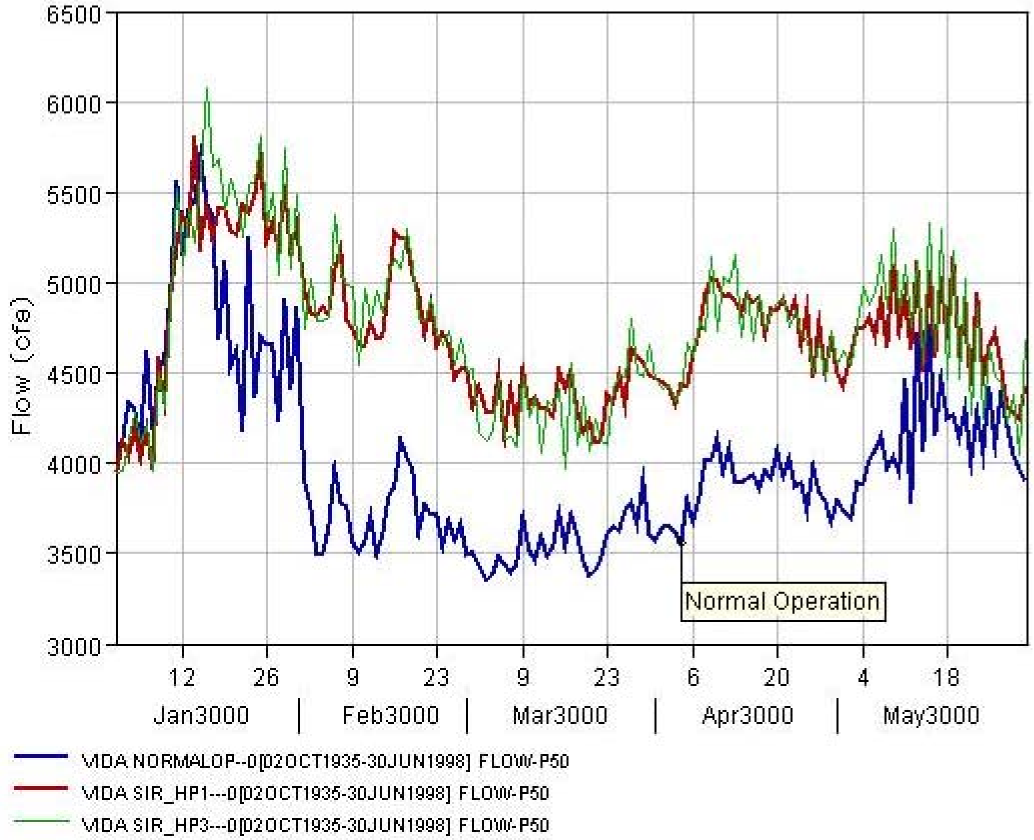

Figure 13 -Comparison of flows at Vida, OR. Normal Operation vs. HP1 and HP3.

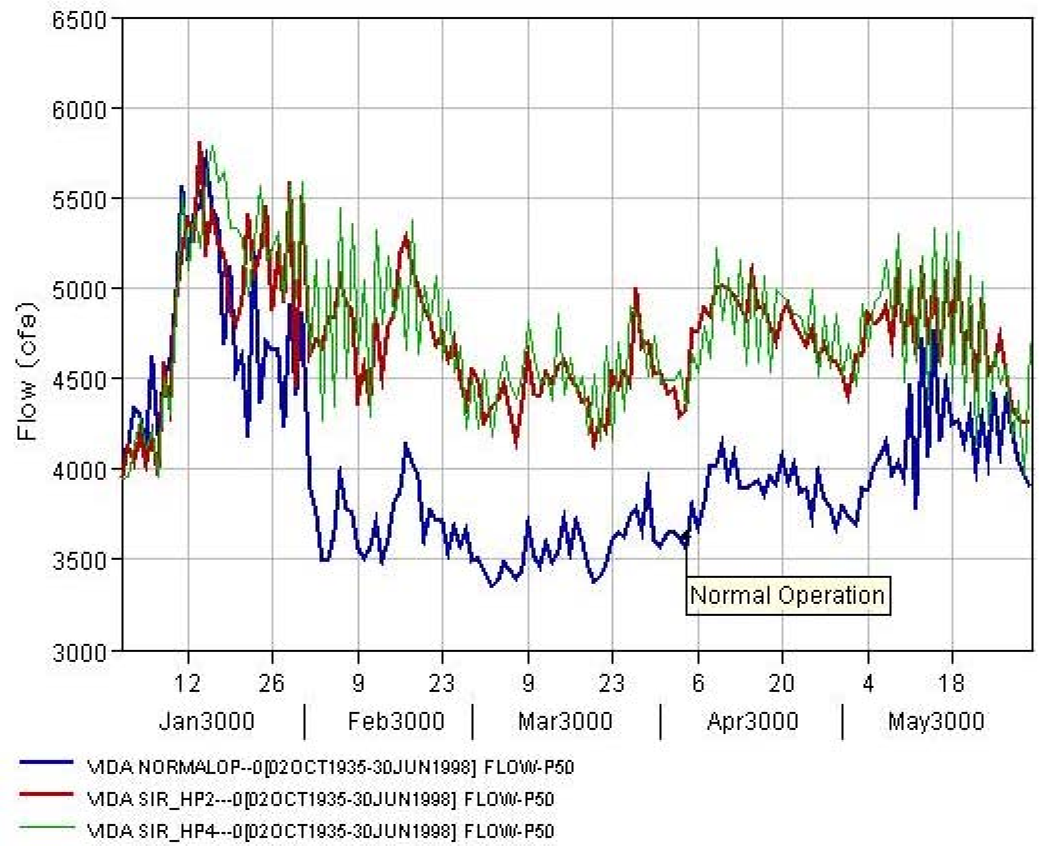

Figure 14 -Comparison of flows at Vida, OR. Normal Operation vs. HP2 and HP4.

<u>Software Used</u> - HEC ResSim, Version 1.02.0004